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PATENT SPECIFICATION

(11) 1248825

1248825

DRAWINGS ATTACHED

(21) Application No. 40162/69 (22) Filed 12 Aug. 1969
(31) Convention Application No. P 17 97 091.1
(32) Filed 14 Aug. 1968 in
(33) Germany (DT)
(45) Complete Specification published 6 Oct. 1971
(51) International Classification H 01 j 37/20 G 02 b 5/00
(52) Index at acceptance
H1D 11X 11Y 19X 19Y 34 44 51
G2J 22

(54) TEMPERATURE-CONTROLLED ORIFICE OR SLIT FOR OPTICAL, ION-OPTICAL AND ELECTRON-OPTICAL INSTRUMENTS

(71) I, HERMANN WOLLNIK, of German nationality, of No. 129, Eichendorffring, Giessen, Federal Republic of Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to temperature-controlled apparatus, and more specifically to an orifice or slit defined by the edges of plates and the width of which is variable by control means that change in length with varying temperature, for use in optical instruments and more particularly in ion-optical or electron-optical instruments.

Such orifices or slits of which one is described in U.S. Patent Specification No. 3,242,796 must be capable of being opened and closed with great precision both for the purposes of adjustment and for operating instruments of variable resolving power. Particularly when incorporated in ion-optical instruments the slit is required to be capable of continuous narrowing to a width of only a few microns. Moreover, the slit must remain symmetrical with respect to the centre plane and its width adjustable without jerks whilst the edges of the plates remain perfectly parallel.

It was hitherto the practice to adjust such orifices and slits with the aid of precision mechanical drive means. Particularly in inaccessible locations in apparatus or diaphragm systems in high vacuum apparatus this involved considerable mechanical complexities. Moreover, such precision mechanical drive means are sensitive to undue stress, such as that imposed upon them when say high vacuum apparatus is being baked out.

With a view to eliminating the required transmission means, cams, servo motors and like mechanical devices and the consequent unavoidable friction and wear, and also for simplifying the overall construction to provide relatively rapid adjustability of the orifice or slit, the arrangement described in the above-mentioned U.S. Patent Specification comprises a control means for adjusting the slit width, in the form of a rod which varies in length in functional dependence upon the temperature to which it is exposed. The changes in length of the rod are transmitted by a lever system which includes numerous retaining springs and a special restoring spring to the plates to produce a relative shift of said plates. However, the general construction of such a slit comprises a multitude of parts and it is still rather complicated.

It is an object of the present invention further to simplify the means for varying the slit width and of thereby reducing the structural size of the entire arrangement.

Mor particularly it is the object of the present invention to eliminate the numerous levers and springs which the above-described prior art slit control apparatus still requires.

Another object of the invention is to ensure that the slit-defining plates can be relatively moved quickly, precisely and symmetrically, whilst their edges are maintained exactly in parallel.

According to the present invention a temperature-controlled orifice or slit for optical, ion-optical or electron optical instruments, comprises support means, a plurality of plates having edges which define therebetween the orifice or slit, said plates being rigidly secured remote from said edges to the support means, the support means being made from a material which has a coefficient of thermal expansion which substantially differs from the coefficient of thermal expansion of the material of which the plates are made, such that change of temperature results in a change of relative positioning of the edges.

Advantageously the temperature of said

plates and said support means are controllable by heating means common to both.

In this arrangement the choice of the materials of which the plates and the support means are made will determine whether the width of the orifice or slit will increase or decrease when the temperature rises.

According to another feature of the present invention the slit may be defined by a pair of plates which rest flush on a baseplate forming said support means, or by two or more pairs of plates disposed in stacks for further enlarging the controllable variability range of the orifice or slit.

In an alternative arrangement more than two plates disposed in pairs that are superimposed in several planes and radially project inwards from a ring forming the support means may together define an orifice in a manner similar to an iris diaphragm.

The baseplate supporting the plates need not be flat. In another embodiment of the invention the side of the baseplate facing the plates may be formed with a central sill and the plates may be provided with a perpendicularly off-angled portion that may be of bimetallic construction. In a modification of this embodiment the sill may be widened to form lateral abutments for the bimetallic parts of the plates.

The plates may be flat and rest in coplanar disposition on a flat baseplate or they may be disposed in different planes and rest on a correspondingly stepped baseplate. In the latter case the inner edges of the plates may be arranged to overlap so that notches in the edges of the plates will define specially shaped orifices for the passage therethrough of the rays or beams.

For achieving the widest possible variability range for the width of the orifice or slit, the baseplate may consist of a material having a low coefficient of thermal expansion, such as molybdenum, and the plates of a material having a large coefficient of thermal expansion, such as nickel, copper, aluminium and the like, provided it is desired to narrow the slit at rising temperatures.

Alternatively, if it is desired that the orifice or slit should widen at rising temperatures, then materials will be so chosen for the baseplate and the plates that the relative magnitudes of the coefficients of thermal expansions are reversed. Moreover, the variability range of the orifice or slit width can be further enlarged by constructing the plates or parts thereof of a bimetal.

The width of the orifice or slit defined by the plates can then be controlled by the heating means that are provided.

The temperature may be raised by heating the support means in any way known in the art, for instance by the direct passage of a current through the baseplate, by electron or ion bombardment, by indirect heating with special heating elements, by radiant or inductive heating or by heating the entire vessel or room in which the orifice or slit is being used. In the interests of rapidity of slit width adjustment heating should preferably be so performed that substantially greater heating power is employed at temperatures that are still remote from the required temperature level than at temperatures close to the required temperature level.

Control loops of a kind conventional in systems control readily permit a constant slit width to be maintained. However, sometimes it may be quite sufficient to operate a heating means from a constant voltage supply.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of a slit defined by a pair of plates made of a material having a different coefficient of thermal expansion from that of a baseplate which carries said pair of plates;

Fig. 2 is a schematic cross section of the slit according to Fig. 1;

Fig. 3 is a schematic cross section of a modification of the arrangement according to Figs. 1 and 2, which permits the variability range of the slit width to be substantially enlarged;

Fig. 4a is a top plan view of a pair of plates of particular shape for defining a square orifice;

Fig. 4b is a cross section thereof;

Fig. 5 is a top plan view of an orifice defined by a plurality of plates mounted on a supporting ring so as to extend radially therein;

Fig. 6 is a perspective view of a slit of which the width can be varied by the deflections of a pair of plates consisting partly or completely of bimetal;

Fig. 7 is a schematic cross section of a slit according to Fig. 6 at a given temperature;

Fig. 8 is a view similar to that shown in Fig. 7 but showing the slit after the temperature has changed;

Fig. 9 is a schematic representation of a slit according to Fig. 1 in which the slit width is variable by the flexing of the plates when the temperature changes;

Fig. 10 is a similar view showing the slit after a temperature change, and

Fig. 11 is a cross section of an arrangement resembling that shown in Fig. 6, comprising abutments for cooperation with the bimetal portions of the plates.

Fifs. 1 and 2 show an orifice or slit formed by a baseplate 1 and two plates 2 and 3, baseplate and plates having different coefficients of thermal expansion. The baseplate 1 has an opening 6 through which light or a particle stream can pass. A slit 5 is defined above the opening 6 between facing edges 2′ and 3′ of the plates 2 and 3 which are secured to the

baseplate 1 by means of screws 4 and 4′. The plates 2 and 3 may be thin e.g. 5×25×0.1 mm in size. The thickness of the baseplate 1 may be substantially greater. The width of the slit 5 is adjustable to within a few μ.

Fig. 2 illustrates the manner in which the slit functions. Let it be assumed that the width d of the slit 5 has been adjusted at a given temperature level to a given value. Two cases can then be distinguished:—

I. Either the coefficient of thermal expansion of the plates 2 and 3 exceeds that of the baseplate 1. When the temperature rises above the initial temperature level the baseplate 1 will expand but the expansion of each of the plates 2 and 3 due to this temperature change will be greater owing to their higher coefficient of thermal expansion. Consequently the width d of the slit 5 will become less.

II. Or the coefficient of thermal expansion of the plates 2 and 3 is less than that of the baseplate 1. The width of the slit 5 will then change in the opposite direction.

A particularly useful form of construction comprises a baseplate made for instance of molybdenum and plates consisting for instance of nickel, copper or aluminium. If a slit constructed as shown in Figs. 1 and 2 is adjusted at room temperature to about 0.1 mm and assuming that the distance between the screws 4 and 4′, i.e. between the points of affixation of the plates on each side of the slit 5, is 2 cms, then the width of the slit will change by about 0.2 μ/°C. At a temperature of the slit of about 500°C, which is a favourable temperature for operating a mass spectrometer (at this temperature the slits remain free from adhering surface impurities) the slit width in case I will close to a few μ if the above-mentioned materials are used.

By a combination of materials of different coefficients of thermal expansion slits which have varying temperature/slit-width characteristics can be produced.

Fig. 3 shows an arrangement in which the slit width can be varied within a wider range than in the arrangement according to Fig. 2. Two plates 36 and 37 having a coefficient of thermal expansion b are affixed to a baseplate 31 having a coefficient of thermal expansion a. These plates 36 and 37 carry a further pair of plates 38 and 39 having the coefficient of thermal expansion a and to these are affixed slit-defining plates 32 and 33 which are more closely spaced than the other plates and which again have a coefficient of thermal expansion b. The plates 37 and 39 and 36 and 38 are securely connected to each other at points A and B (by soldering or welding) and at C they are secured to the baseplate 31. They are firmly pressed on the baseplate 31 by means of screws 34 and 34′. Assuming that the coefficient of thermal expansion a is less than b and that the distances d_1, d have been adjusted at a given temperature, then the distance d_1 between the plates 36 and 37 will change analogously to the slit width in Fig. 2 when the temperature rises. The plates 38 and 39 will change their length in the same direction as the baseplate 31, whereas the plates 32 and 33 will expand codirectionally with the plates 36 and 37. Consequently the change in the width of the slit d will be twice that in the length of the distance d_1. The same temperature change in this latter arrangement will therefore produce twice the change in the slit width obtained in the arrangement according to Fig. 2. By providing further analogously stacked and interconnected pairs of plates the change in slit width can be multiplied.

By giving the edges of the plates 42 and 43 a particular shape shown in Fig. 4a square orifices, as are desirable for instance in electron microscopes, can be created instead of elongated slits. It will be understood from Fig. 4b that the face of the baseplate 41 carrying the plate 42 and 43 is stepped, and that said plates are therefore relatively offset in different planes. The edges of the plates defining the slit are each provided with central notch 42′ or 43′ of triangular shape so that according to the shape of the notches the overlapping edges will define a rectangular, square or rhombic orifice for the passage therethrough of the rays.

By the provision of a plurality of plates 52 to 59 affixed to a baseplate modified to form a supporting ring 51, as shown in Fig. 5, and by location of the plates in pairs in different offset parallel planes, an orifice resembling an iris diaphragm for very small openings can be created by appropriately selecting the length of the plates. Although thermal expansion of the supporting ring 51 operates to withdraw the radially remote ends of the plates from the centre of the supporting ring 51, the plate edges forming the orifice will nevertheless move closer towards the ring centre if their coefficient of thermal expansion exceeds that of the ring 51. Otherwise the arrangement functions in the same way as that shown in Fig. 2.

In the embodiment illustrated in Figs. 6, 7 and 8 a baseplate 61 formed with a central sill 68 traversed by an opening 69 for the passage therethrough of a particle beam carries two plates 62 and 63 and the edges of said plates defining a slit 65 bear flush under flexural tension on the face of the sill 68. This tension is generated by a portion 66 or 67 of each plate remote from the slit 65 being bent perpendicularly downwards and this bent portion which is affixed to the baseplate 61 being of bimetallic construction so that it will flex when the temperature changes. The width d of the slit 65 will therefore change accord-

ing to the degree of flexing of these portions.

Fig. 9 and 10 illustrate a modification of the slit according to Fig. 1 in the case of which the entire plates 92 and 93 themselves are bimetallic and bend when the temperature changes. They thus cause the slit width to change, as indicated in Fig. 10, the change exceeding that attainable according to Fig. 1.

Fig. 11 shows a slit of which the width *d* is coarsely variable within a given temperature range and finely variable as a function of temperature in another directly adjoining temperature range. In a baseplate 111 which is formed with a central sill 114 resembling that of the baseplate in Fig. 6, so that the edges of the plates 112 and 113 forming the slit 115 can bear flush against the face of the sill 114, the latter is widened and forms lateral projections 118 and 119 which serve as abutment faces for perpendicularly off-angled bimetallic portions 116 and 117 of the plates. When the temperature rises the plates 112 and 113 are first moved fairly rapidly across relatively large distances, such as 1 mm. However, above a given temperature, such as 200°C, the deflection of the bimetallic portions 116 and 117 is intercepted by the lateral projections 118 and 119, and when the temperature continues to rise only the contact pressure increases and the slit width *d* ceases to be affected by the bimetallic portions of the plates. The slit width then changes exclusively by virtue of the difference in thermal expansion between the portions 112 and 113 of the plates and the baseplate 111 and the lateral projections 118 and 119.

The advantage of the proposed orifice or slit over hitherto conventional arrangements is that its overall construction is substantially simpler and more compact and that mechanical drive means are not required, notwithstanding that the plates are very precisely and symmetrically adjustable in relative parallelism.

WHAT I CLAIM IS:—

1. A temperature-controlled orifice or slit for optical, ion-optical or electron optical instruments, comprising support means, a plurality of plates having edges which define therebetween the orifice or slit, said plates being rigidly secured remote from said edges to the support means, the support means being made from a material which has a coefficient of thermal expansion which substantially differs from the coefficient of the thermal expansion of the material from which the plates are made, such that change of temperature results in a change of relative positioning of the edges.

2. A temperature-controlled orifice or slit, as claimed in claim 1, wherein the temperature of said plates and said support means are controllable by heating means common to both.

3. A temperature-controlled orifice or slit, as claimed in either of claims 1 or 2, comprising a pair of plates which rest flat on a baseplate forming said support means and provided in the region where the slit is formed with an opening for the passage therethrough of light rays or particle beams.

4. A temperature-controlled orifice or slit, as claimed in either of claims 1 or 2, comprising two or more pairs of plates disposed in different parallel horizontal planes, the slit-defining edges of a first pair of plates made of a first material and secured to said support means which are made of another material being attached to the corresponding ends of a second pair of plates of said other material resting on said first pair of plates and the ends of said second pair of plates remote from the slit being attached to the corresponding ends of a pair of plates made of said first material and defining said slit between them.

5. A temperature-controlled orifice or slit as claimed in either of claims 1 or 2, comprising more than two plates radially arranged within a supporting ring constituting said support means, said jaws being disposed in pairs relatively offset parallel planes and having edges of said plates facing the centre of said supporting ring to define an orifice in the manner of an iris diaphragm.

6. A temperature-controlled orifice or slit as claimed in claim 3, wherein said baseplate is formed with a central sill providing a bearing face upon which the slit defining edges of said plates bear under tension, the ends of said plates remote from said slit are bent at right angles and form a bimetallic portion which is affixed to said baseplate.

7. A temperature-controlled orifice or slit, as claimed in claim 6, wherein said bearing face of said central sill is laterally widened and forms lateral abutments for said bent bimetallic portions of said plates.

8. A temperature-controlled orifice or slit, as claimed in claim 3, wherein said baseplate has a stepped bearing face for said plates to support said plates in two relatively offset parallel planes, and the slit-defining edges of said plates are each provided with a central triangular notch so contrived that the notches in the overlapping edges of said plates cooperate to define a rectangular, square or rhombic orifice for the passage therethrough of the rays or the beam.

9. A temperature-controlled orifice or slit, as claimed in either of claims 1 or 2, wherein the face of a baseplate forming said support means is flat and carries two cooperating coplanar slit-defining plates.

10. A temperature-controlled orifice or slit, as claimed in claim 9, wherein the slit-defining edges of said plates are straight and parallel.

11. A temperature-controlled orifice or slit,

as claimed in claim 9, wherein the slit-defining edges of said plates are wedge-shaped to form knife edges.

12. A temperature-controlled orifice or slit, as claimed in either of claims 1 or 2, wherein said support means are made of a material having a small coefficient of thermal expansion, whereas said plates are made of a material having a high coefficient of thermal expansion.

13. A temperature-controlled orifice or slit, as claimed in claim 12, wherein the material of the support means is molybdenum.

14. A temperature-controlled orifice or slit as claimed in claim 12, wherein the plates are made of a material selected from nickel, copper and aluminium.

15. A temperature-controlled orifice or slit, as claimed in either of claims 1 or 2, wherein said plates are entirely of bimetallic construction.

16. A temperature-controlled orifice or slit, as set forth in claim 6, wherein the portions of said plates which are not bent are made of a material having a different coefficient of thermal expansion from that of said baseplate.

17. A temperature-controlled orifice or slit, substantially as herein described with reference to and as illustrated by the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1971.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1248825 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

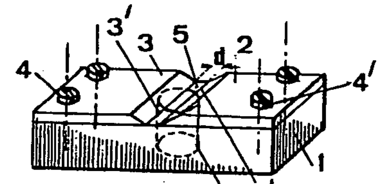

FIG.1

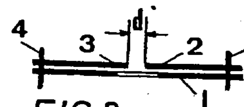

FIG.2

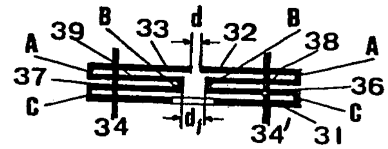

FIG.3

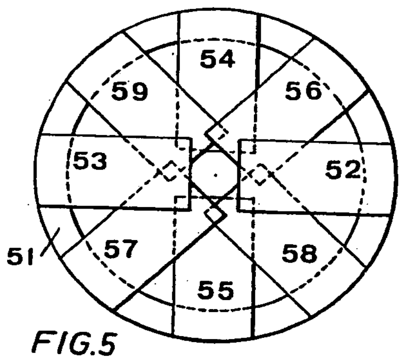

FIG.5

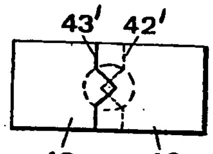

FIG.4a

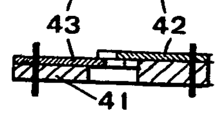

FIG.4b

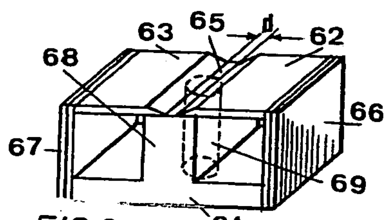

FIG.6

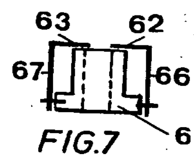

FIG.7

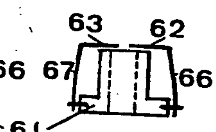

FIG.8

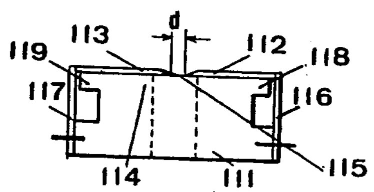

FIG.11

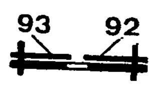

FIG.9

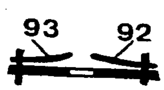

FIG.10